Experimental and computational methods to reveal the impact of applied compression on cells

Sevgi Onal,* Maan M. Alkaisi and Volker Nock

Department of Electrical and Computer Engineering, University of Canterbury

* sevgi.onal@pg.canterbury.ac.nz

Evidence continues to emerge that cancer is not only a disease of genetic mutations, but also of altered mechanobiological profiles of the cells and microenvironment. Biomechanical forces regulate tumor microenvironment by solid stress, matrix mechanics, interstitial pressure and flow[1]. Compressive stress by tumor growth and stromal tissue alters the cell deformation, and recapitulates the biophysical properties of cells to grow, differentiate, spread or invade. Such a solid stress can be introduced externally to change the cell response and to mechanically induce cell lysis by dynamic compression. In this work we report a microfluidic cell-culture platform with an integrated, actively-modulated actuator for the application of compressive forces on cancer cells. Our platform is composed of a control microchannel in a top layer for introducing external force and a polydimethylsiloxane (PDMS) membrane with monolithically integrated actuators. Characterization of the mechanical actuation experimentally and computationally showed the capability of the platform to perform both, repeated dynamic cell compression at physiological pressure levels, and end-point mechanical cell lysis. Mechanobiologically-related morphological changes (e.g. nuclei and membrane expansion) that occur while cells are deforming and the resultant cell viability under mild and then higher pressures applied in cyclic manner, with cell regions present within the same chamber acting as direct control, were all captured. Finally, changes in cancer bionanomechanics in response to applied compression is under further investigation at protein level.

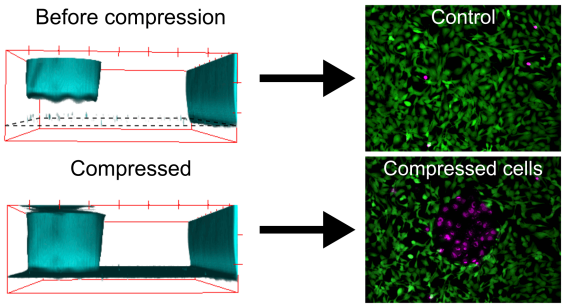

Figure 1: Graphical abstract showing the concept of applying compression with an integrated PDMS actuator in a microfluidic channel (Cyan). Green: Live cells, Magenta: Dead cells.

References:

1. A.C. Shieh, *Ann. Biomed. Eng.,* **2011**, *39*, 1379-1389.